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Design and implementation of Orchard Internet of Things based on LoRa

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ABSTRACT:

With the rapid development of agricultural and rural modernization, intelligent and information-based management has gradually taken root and sprouted in agricultural production. This paper proposes the development and application of agricultural Internet of Things in orchard management, and designs realistic system functions including information collection, descending command execution and upper computer interaction. The three-layer structure is abstracted, and the upper computer at the PC end can interact with users. In order to achieve the purpose of remote interaction, the system considers the use of cloud platform to break through the distance barrier and achieve real remote interaction. Experiments show that the LORA-BASED orchard IoT system designed in this paper has outstanding advantages such as strong portability, low energy loss, long communication distance and strong interaction, and has a good application prospect in the field of orchard IoT monitoring.

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I. INTRODUCTION

With the development of Internet of Things technology and the gradual application of Internet of Things industry in production and life, the use of Internet of Things technology for intelligent monitoring and scientific management of agricultural environment has become an inevitable trend and an important means for the development of modern agricultural grain and fruit and vegetable industry in China. The goal of intelligent orchard is to monitor environmental temperature and humidity, light intensity, soil moisture and other parameters that will be closely related to fruit tree growth, and realize data monitoring, collection, transmission and regulation. Through this means, information resources are transformed into productive forces, and the industrial structure of orchard production is changed, from labor-intensive and environment-dependent agricultural production mode to a modern orchard industry that can be monitored, measured, prevented and controlled by human. From the aspect of orchard management, this not only reduces the management cost, strengthens the key position of controllability in orchard management, but also makes scientific management become a basis to follow. From the field of agricultural production, the improvement of fruit quality, the increase of orchard yield provides a stepping stone of science and data.
Abroad, due to the industrial base of western countries is better, agricultural modernization has also been put on the agenda early.
20 world 70's, "windmill country" Holland began to send force in the field of agricultural greenhouse, took the lead in the research and development of the CECS computer control system for greenhouse. This system realizes the automation of greenhouse environment management. In the 1980s, Motorola led the research and development of an automatic irrigation system, which gained a large market application in the United States. The system was tested in Westport County, Indiana, for a long period of time in the field to verify its automated connection to sprinkler irrigation systems after measuring soil moisture. When the soil water content is lower than the set value, the moisture sensor in the soil will get the data to the preset logic processing circuit (later replaced by the microprocessor), automatic control system starts, irrigation.
China's agricultural Internet of Things started late and developed slowly, and has been in a backward state due to unbalanced industrial development and other factors. However, Chinese scientists have not stopped the study of related aspects, some of which are prominent, can be listed and described, with good enlightenment and leading role. At the end of 1990s, MAO shenjian et al. developed the first generation of automatic irrigation system on Intel8031, the ancestor of 51 single chip microcomputer. This system not only realized the function of timing irrigation, its outstanding point is that it also has the function of measuring soil moisture. Since the

beginning of the new century, China has actively developed the agricultural Internet of Things, and the development trend of the nongovernmental agricultural Internet of Things has been positive and positive. In order to win the battle against poverty, Sunliu Town, Minquan County, Henan Province, adapted measures to local conditions, took advantage of the local tradition of planting fruits and vegetables, and actively developed the Internet of Things greenhouse project, which increased local farmers' income. At the same time, academia is also actively studying. Professor Zhang Ping chuan from the School of Information Engineering, Henan University of Science and Technology designed an orchard Internet of Things system for fruit quality improvement at fruit ripening stage by taking advantage of the physical effect of water mist evaporation and cooling.

In view of the current domestic research status, this paper designs an Orchard IoT system based on LoRa from two aspects of hardware and software, using the latest LoRa wireless communication technology, sensor technology, cloud platform technology and other related technologies.

II. SYSTEM DESIGN SCHEME

2.1 Overall system design

The basic function of this design is to monitor and collect the environmental factors of the orchard -- temperature, air humidity, light intensity and soil humidity in real time, and the information collection layer communicates through wireless network, and the collected information is finally transmitted to the upper computer and displayed to the user. Users can monitor the orchard information in real time, conveniently and remotely, and compare the collected information with the preset threshold value, and automatically or manually control the pump system switch for irrigation. Specific requirements for system functions are as follows:

(1) The information perception layer is the collection of environmental information and the basis for judging whether irrigation is carried out or not. Real-time and accurate acquisition of fruit tree growth environment parameters is the premise of realizing intelligent orchard. The task of information collection is accomplished by deploying various sensors to collect information in the orchard.

(2) The acquisition node and the upload node can communicate wirelessly. At this time, the wireless transmission mode between nodes is required to have the characteristics of long communication distance, low power consumption, high security and stable signal.

(3) The collected information can break through the distance barrier and be collected to the upper computer in real time and without damage.

(4) The core of this design is to use the collected orchard environmental data to realize the irrigation function of the orchard automatically or manually, requiring that the system can realize the command down and control the pump terminal.

The hierarchy is shown in Figure 1.

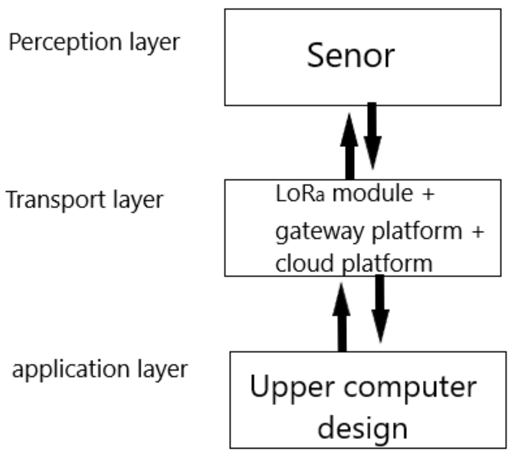

Figure 1 System hierarchy analysis diagram

This design adopts the STM32 as main control chip of orchard IoT system, by the air temperature and humidity, soil moisture sensor, light intensity sensor, water pump switch controller, wireless communication module (Lora), Wi-Fi gateway module, cloud platform, PC and so on, implements the information acquisition and

intelligent management of Internet of orchard, The specific functions and working principles are as follows:
Wireless communication between nodes adopts LoRa technology for data transmission, and then transmits node data to the superior computer through the transmission layer. The information perception layer is the terminal of the orchard environmental information acquisition, which is composed of sensors, STM32 microcontroller, etc. Each sensor arranged in the park collects environmental information of the park at A certain interval, and converts the collected analog signals into digital signals through A/D converter in MCU for further transmission. The sensor layer collects the data collected by the sensor. When the set time is reached, the microprocessor sends the data to the gateway module through LoRa protocol. The gateway module consists of STM32 microprocessor, LoRa module, Wi-Fi module and cloud platform, which is mainly responsible for wireless communication with the sensing layer and the upper computer. Lora at the transport layer receives the data from the sensor, processes the received data through the microprocessor, and then packages the data to the cloud through the Wi-Fi module. The upper computer connects to the cloud, and receives the data and processes the data for the user to watch after the match is successful. According to the collected data, users can choose automatic or manual mode to control the pump switch and carry out orchard irrigation operation. In the automatic mode, the collected soil moisture data is compared with the pre-set threshold value of soil moisture. If the collected data value is lower than the pre-set threshold value, the upper computer will automatically lower the water pump to open the command for irrigation operation.

2.2 Cloud Platform Solution

In addition to the long-distance communication between the sensing layer and the transmission layer, a perfect orchard IoT system should also achieve remote control. Therefore, the communication requirements between the transmission layer and the application layer should also be taken into account. Sometimes the application layer and the transmission layer are not in the same geographical or network area. We consider using cloud platform to break through this barrier.
Guyu cloud transparent transmission platform to provide a good free remote network debugging assistant. And provides simple transparent transmission function. As we all know, Socket communication uses the communication mechanism between the client and the server, and the client only needs two parameters to establish a connection with the server. One parameter is the IP address of the server, and the other parameter is the port number to communicate with. Therefore, when the facility communicates with the Guyu Cloud transparent transmission system as a client, the system adopts a verification method called registration packet to identify the data source and whether the client device is legitimate. After each connection, it sends a packet of data, which must be written and sent according to the system rules. Cloud systems use the contents of this packet to identify client devices. The registration package format is as follows: ep=deviceId&pw=devicePw deviceId (deviceId) and devicePw (device password) are two variables. Users can customize these two variables, or use the variable definitions generated by the system by default. The device number of the upper computer in this paper is D4UT9UZF83FM7XN5. The device number of the gateway module is LKXTAU3CDSMPPYSL, and the password is 123456.

III. SYSTEM HARDWARE CIRCUIT DESIGN

3.1 STM32F103C8T6 controller

The important part of the single chip is its internal chip, generally relatively small, internal integrated with arithmetic unit, controller, memory, input and output ports and some other logical components. Traditional SCM is small in size, low in power consumption and high in operation speed. This system uses STM32F103 series of STM32F103C8T6 chip as the main controller. The circuit diagram of STM32F103C8T6 is shown in Figure 2.

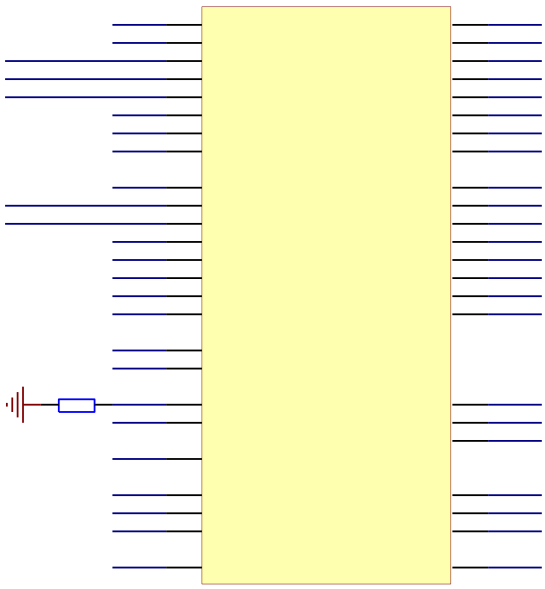

Figure 2 STM32F103C8T6 circuit diagram

3.2 Wi-Fi module

Atk-esp8266 is a high-performance serial - wireless (UART-Wi-Fi) module. It can be loaded with its own software applications, and can format all Wi-Fi functions with a single AP interface. The ESP8266 is shown in Figure 3. The ESP8266 can be booted directly from external flash memory. In other cases, when undertaking the task of Wi-Fi adapter, such as embedded system development, it can be added to the module unit containing MCU for easy and quick connection. The ESP8266 is highly integrated on the chip, and the package is suitable for development, as simple external circuit packaging can be achieved in use. ESP8266 is a self-contained Wi-Fi solution with a highly integrated on-chip system. The circuit diagram is shown in Figure 4.

Figure 3 Wi-Fi module ESP8266

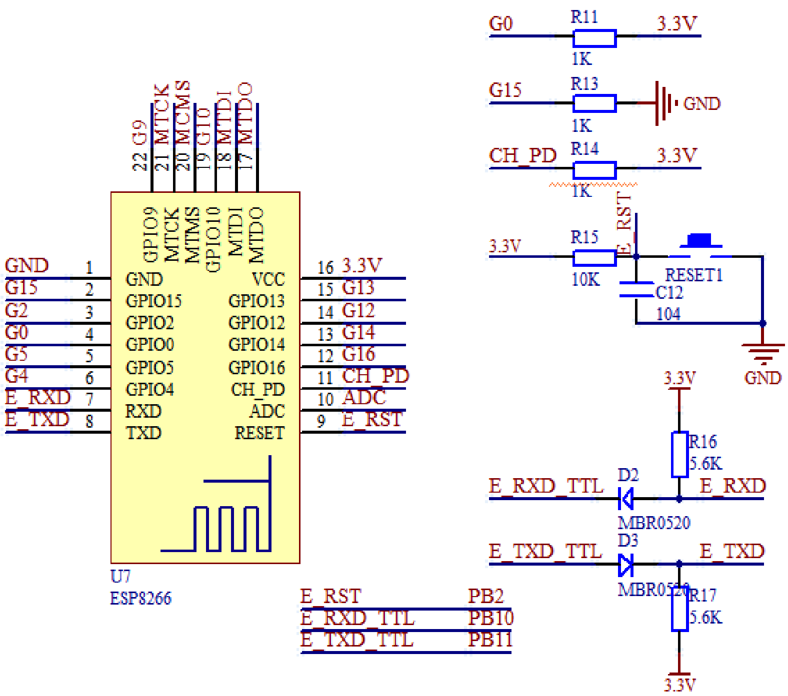

Figure 4 Wi-Fi module circuit diagram

This system using the Wi-Fi module to realize the remote control of the basic principle is: the node will be collected environmental data through the wireless transmission LoRa gives information turned over to the module, information turned over to the module through the Wi-Fi module connected to cloud, cloud platform and real-time data sent to the remote client, remote client PC to understand and control orchard environment.

3.3 LoRa module

The ATK-LORA-01 wireless serial port module selected in this system is a LORA wireless serial port module launched by ALIENTEK. It has the characteristics of small size, low power consumption, high performance and long communication distance. Atk-lora-01 is shown in Figure 5.

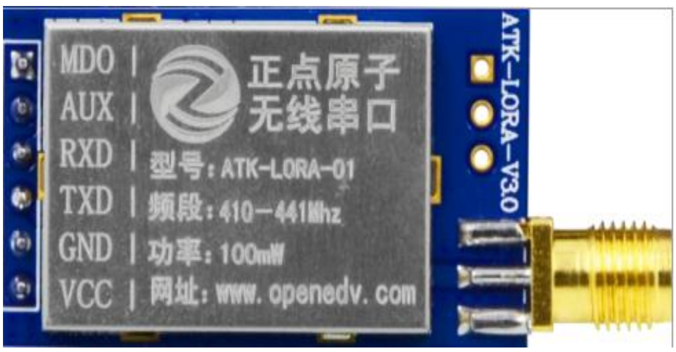

Figure 5 Atk-lora-01 Physical picture of a wireless serial port module

This module uses the SX1278 spread spectrum chip, which is a RADIO frequency chip in the ISM band. The chip has the advantages of long communication distance, stable signal, high safety and efficiency. The module has a total of 32 channels, you can modify the working mode, serial port rate and other parameters through AT instruction. Operating frequency 410mhZ-441mhz, in which stepper channel adopts 1Mhz frequency as standard, and supports firmware upgrade function. The chip inside the module has its own filter circuit to achieve signal stability and eliminate interference.

3.4 T/H Sensor

The temperature and humidity sensor in this system is DHT11, which is easy to learn and familiar to everyone, as shown in Figure 6. It is a sensor that measures temperature and humidity together.

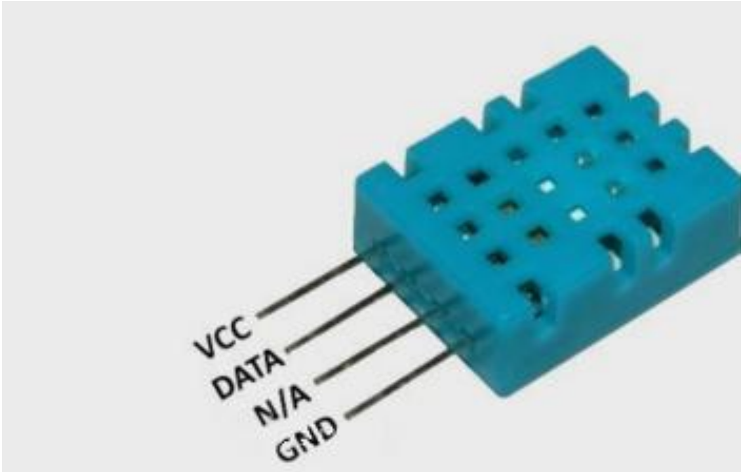

Figure 6 T/H Sensor DHT11

3.5 Light Sensor

The system selects GY-30 as the light sensor module, and integrates BH1750FVI light sensor inside the module. BH1750 has photosensitive diode in charge of light sensitivity, uses operational amplifier to obtain the analog value of weak current change, and completes the acquisition of digital signal through AD converter. Used to provide the reference frequency. The physical figure of GY-30 module is shown in Figure 7.

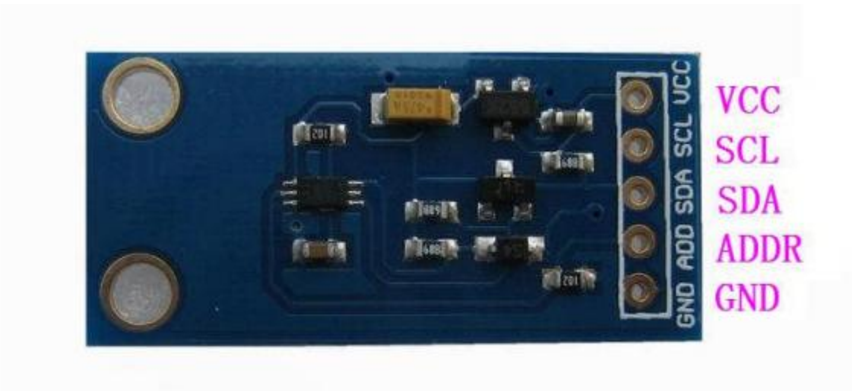

Figure 7 GY - 30 real figure

3.6 Soil moisture sensor

The soil moisture sensor is divided into two parts, one part is the waterproof probe, the other part is the steel probe which has been treated with rust. It can be laid in the orchard soil as an adult. At the same time, it can play a role in measuring moisture content in shallow soil and deep soil. The output sensor model of this system is YL-69. The physical picture is shown in Figure 8.

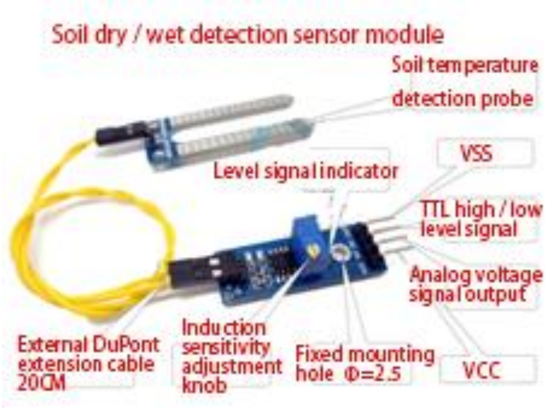

Figure 8 Diagram of soil moisture sensor YL-69

IV. SYSTEM PROGRAMMING

4.1 Main program design

Analysis of this system, there are information collection, information transmission, upper computer interaction, and downlink command execution four functions, divided into node terminal, gateway and upper computer to achieve. The transmission of information is essential for all other functions. If the information transmission function is compared to the body, then the information collection function and the downstream command execution are two hands, one for holding data, the other for doing things. Simply put, it's one body and two wings, and the upper computer is the brain. The overall functional flow framework is shown in Figure 9.

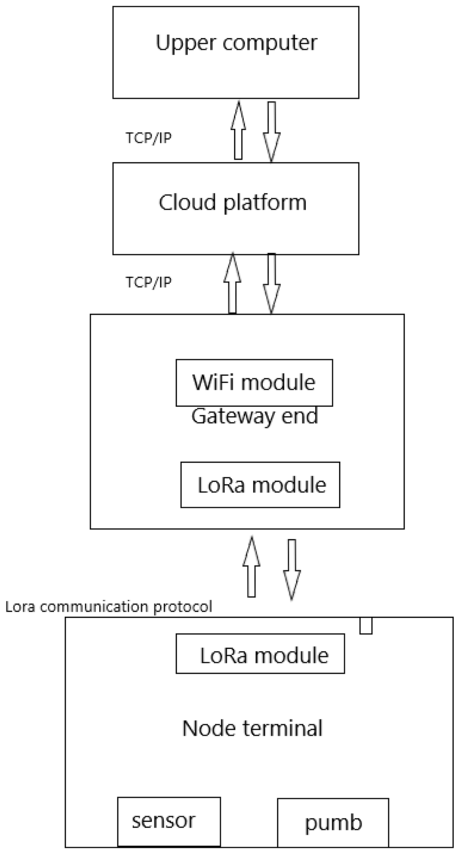

Figure 9 Overall functional flow framework

4.2 Terminal module program design

The terminal module in this design is divided into two parts. The first part is to collect the environmental information of the orchard by sensor. The sensor is connected with the acquisition module through the I / 0 interface, which is mainly responsible for monitoring the environment of the park and collecting data once within the set time (500 milliseconds).The circuit diagram of the terminal module was drawn in Altium Designer Summer09 and the code was written in Keil5.

4.3 Gateway Module design

The gateway module is an important link connecting the upper computer and the terminal node, and is the core of the whole system. On the one hand, the gateway communicates with the node terminal through Lora module; on the other hand, the gateway connects to the cloud through Wi-Fi module, and then keeps communicating with the upper computer through the cloud, ensuring the possibility of remote monitoring and control of the system. LoRa module transmits data with THE Wi-Fi module through the STM32 microprocessor, and the Wi-Fi module communicates data with the upper computer through the transparent transmission function of the cloud platform. First, after powering on, the Wi-Fi module will automatically connect to Wi-Fi according to the Service Set Identifier (SSID) and password recorded in the module in advance. This function is realized by the atk_8266_wifiSTA_test () function. After connecting to the network, the gateway module will log in to the cloud platform through the wifi_regist_cloud() function, and then communicate with the upper computer through the cloud platform. The atk_8266_wifiSTA_test () function and wifi_regist_cloud() function see appendix for specific codes. After connecting to the cloud, the gateway starts to work. The overall working flow chart of the gateway is shown in Figure 10:

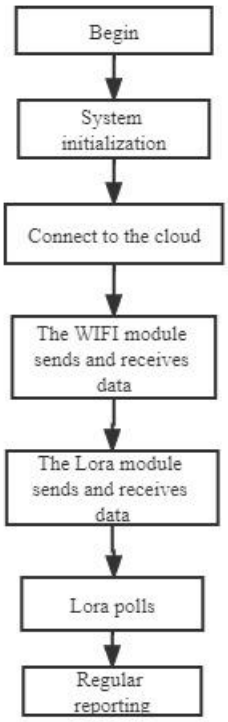

Figure 10 Flowchart of working on the gateway

4.4 Program design of upper computer terminal module

4.4.1 Function design of upper computer

The upper computer is the main embodiment of the client and user interface in the whole software system. First of all, it need to be able to provide an interactive interface, the user can intuitively clear terminals, data were collected from the node according to this system adopted by the sensor, the PC of the interface should have sensor parameters shows that according to this system set by the function, can be manually or automatically control water pump switch, so to have automatic and manual mode selection module, There should also be a module for setting the threshold value of soil moisture to realize automatic control. In addition, as the main tool of remote control, the upper computer should have the function of accessing the Internet by connecting the specified IP address and port, and the upper computer should also have the function of sending commands to the terminal, so as to realize real-time interaction.

4.4.2 Function realization of upper computer

The upper computer based on Microsoft Visual Studio2013 environment with C++ language development, generate. Exe executable file, named tcpclient.exe. It has been introduced before that this system uses Guyu cloud platform to realize the connection between the gateway module and the upper computer. The registration interface between the upper computer and the cloud is shown in Figure 11.

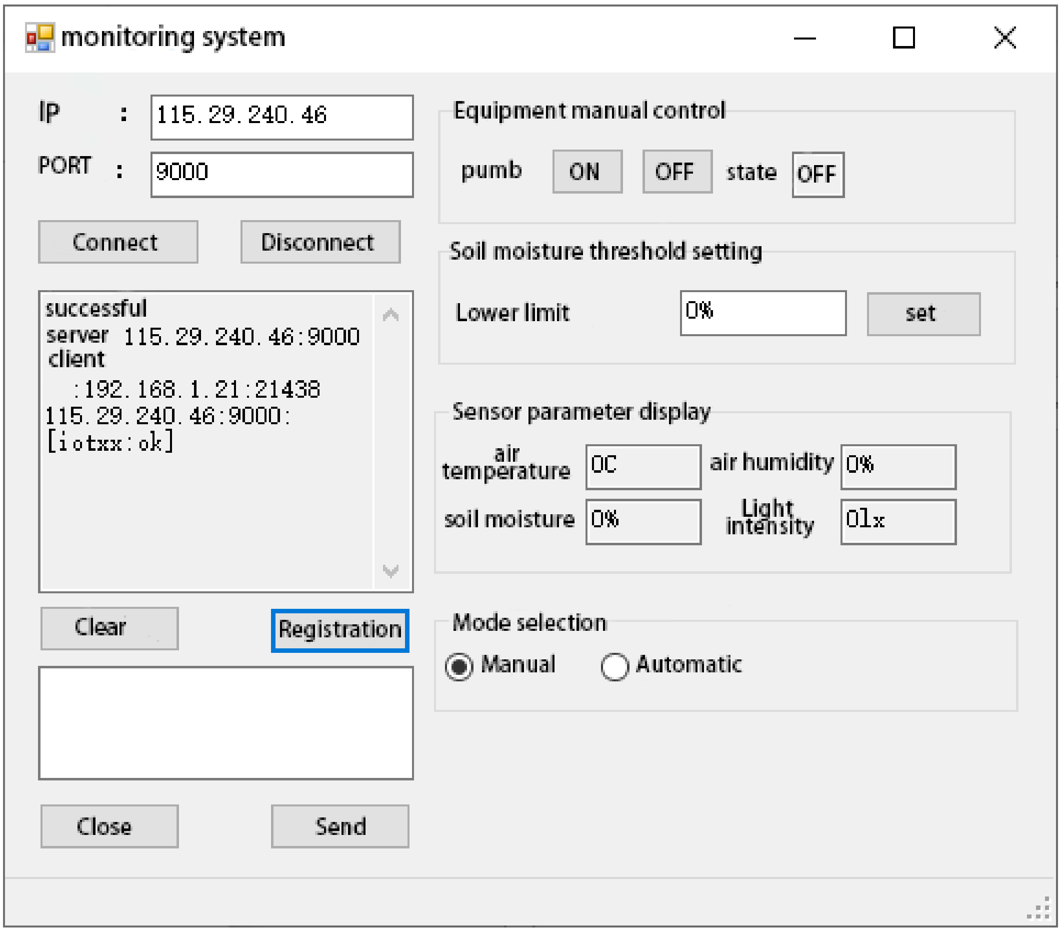

Figure 11 Connect the upper computer to the cloud registration interface

V. SYSTEM IMPLEMENTATION AND DEBUGGING

5.1 System Integration

System integration refers to the use of hardware equipment to connect each subsystem or independent physical devices, so that it has smooth and smooth electrical characteristics, the system integration is to assemble and weld the electrical components needed by the system. Figure 12 shows the physical figure of the terminal node module after welding, and Figure 13 shows the physical figure of the gateway module.

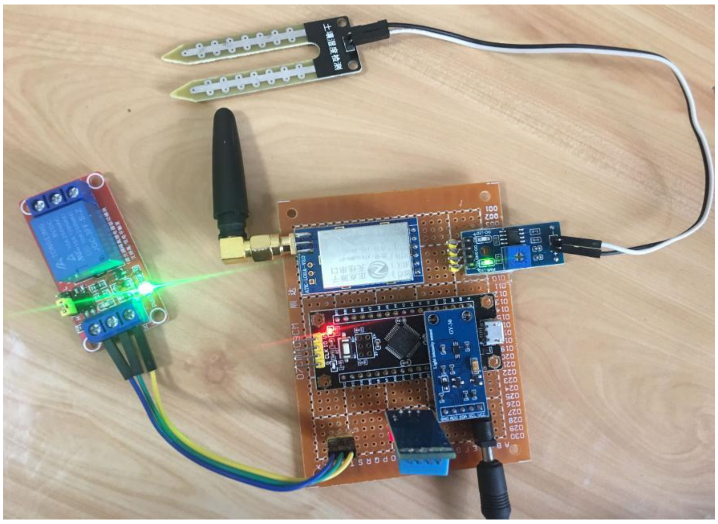

Figure 12 Physical diagram of terminal node module

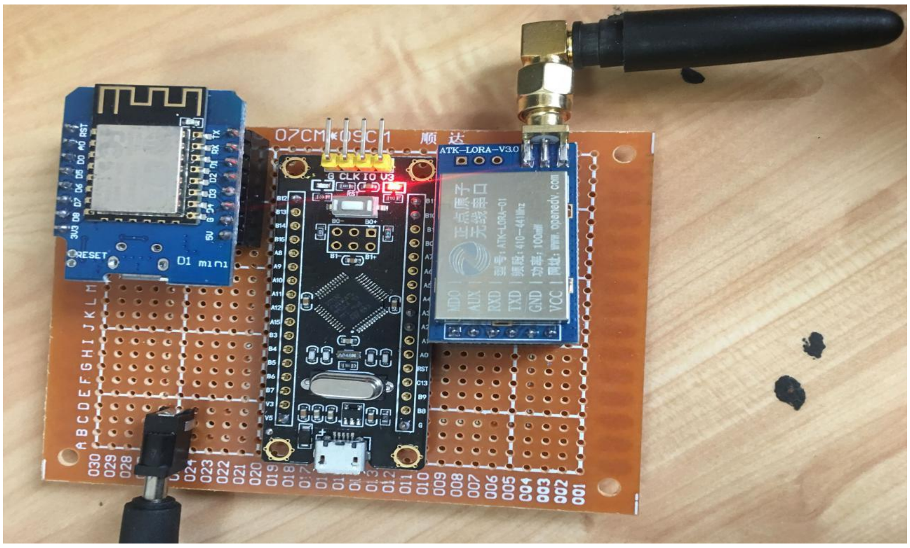

Figure 13 Physical diagram of the gateway module

5.2 Test and debugging

In order to verify the function of the system, the author came to two orchards with different moisture content near his residence to carry out field tests. The devices used in this test include a charging bank to supply power to the terminal module, a laptop to test the realization of upper computer functions and power to the gateway module, and a connected mobile phone to provide hot Wi-Fi to the gateway module and computer.
The experiment was first carried out in a relatively dry orchard. The terminal module is deployed in the orchard, the soil moisture sensor is inserted into the soil of the orchard, and the power is powered on through the charging bank. As shown in figure 14.

Figure 14 Testing at Orchard one

Plug the USB power cord of the gateway module into the computer, the gateway module automatically connects to the hot spot of the mobile phone, and at the same time connects the computer to the Internet. Then open the upper computer on the computer to connect to the cloud, and receive the data from the terminal module detection after registration. But the soil moisture was found to be 0.
In order to verify the normal work of soil moisture module, the author decided to come to orchard 2, which has been irrigated with better moisture content, for another test. See Figure 15.

Figure 15 Testing at Orchard two

The test results show that all detection modules work normally. The data of the upper computer is shown in Figure 16.

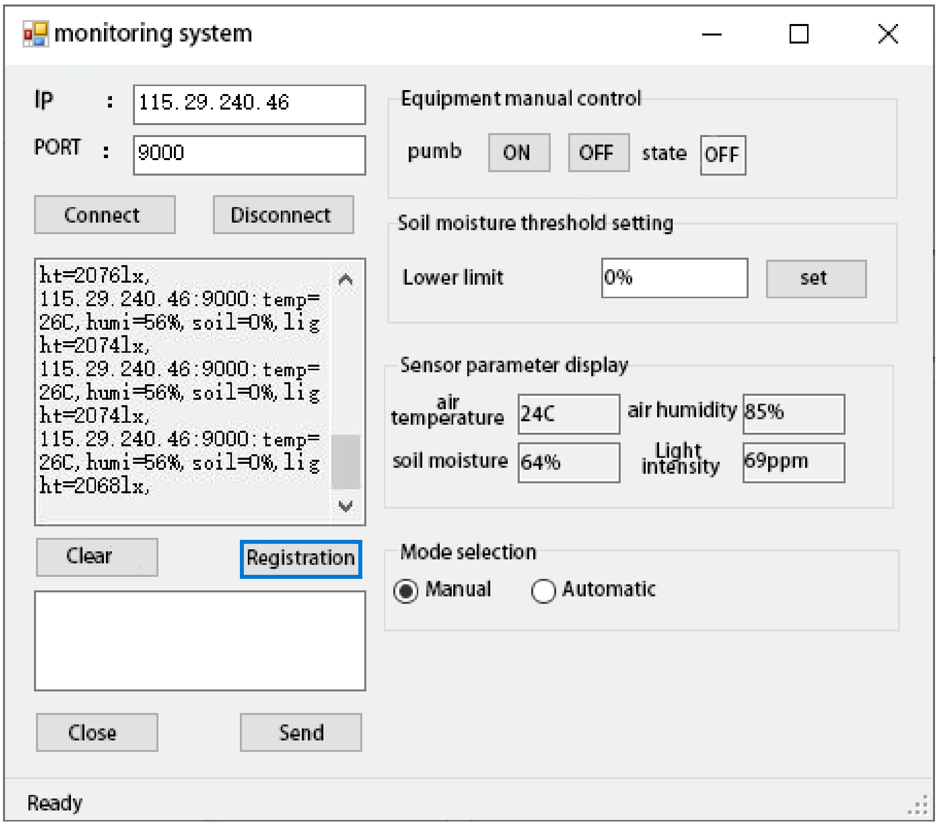

Figure 16 The mainframe data from Orchard two

VI. CONCLUSION

In this paper, an Internet of Things system for orchard environmental monitoring irrigation is designed and implemented by using the open cloud platform and the emerging LoRa technology. The system has the advantages of high-cost performance, high portability, long communication distance and low energy loss. The system is mainly divided into three parts: terminal node module, gateway module and upper computer. Aiming at the actual demand of orchard Internet of Things and the technical bottleneck of data transmission layer, this paper designs a data transmission scheme using LoRa networking and cloud platform. At the same time take into account the interaction application layer and information acquisition layer parallel to give the system design scheme.

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